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REVISION OF PERMIAN ECCA SERIES
CEPHALOPODS, NATAL, SOUTH AFRICA

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ABSTRACT

Cephalopods described as *Discitoceras bowdeni* by Rilett in 1963 have been restudied and are now interpreted as representing ammonoids, most probably of the Permian genus *Paraceltites*. Their presence in the Middle Ecca coal measures suggests a paralic environment for the deposition of these beds.

INTRODUCTION

In 1963, one of us (Rilett) described cephalopods from the Ecca Series¹ of Natal which he interpreted as nautiloids and for which he proposed the name *Discitoceras bowdeni*. The occurrence is in the roof of the Aletta Iron-Ore Mine in the Dundee District of northern Natal.

During a visit to South Africa in July, 1970, Teichert learned of this occurrence from Dr. S. H. Haughton who told him that the specimens probably were in the Natal Museum in Pietermaritzburg. Through the kindness of the director of the Natal Museum, Dr. John Pringle, Rilett was able to send the originals described in his 1963 paper to Teichert who came to the conclusion that the specimens were ammonoids rather than nautiloids. The specimens were submitted

for inspection to Drs. Mackenzie Gordon (U.S. Geological Survey), W. M. Furnish and B. F. Glenister (University of Iowa), and to Professor Adolf Seilacher (University of Tübingen). We are indebted to these colleagues for their advice. Dr. Gordon was especially helpful in narrowing down the possible systematic affinities of the specimens, and Professor Seilacher in the interpretation of diagenetic processes that have affected the shells.

W. M. Furnish and B. F. Glenister reviewed the manuscript and made valuable suggestions regarding the possible age of the specimens. Roger B. Williams drew the map (Fig. 1) from a sketch supplied by Rilett. Michael Fredericks prepared the photographs.

STRATIGRAPHY AND GENERAL GEOLOGY OF THE ECCA SERIES
IN NORTHERN NATAL

The Ecca Series is the second to oldest member of the Karroo System, an immense sequence

of sediments ranging without apparent angular disconformity from the Pennsylvanian to the Upper Triassic. The Ecca Series is divided on lithological grounds into three stages. The rocks of northern Natal (Fig. 1) are part of the northern facies of the series and the Middle Ecca

¹ In South Africa the formal nomenclature recommended by the International Geological Congress is not yet officially adhered to, and local stratigraphic divisions are recognized. The South African Geological Survey uses the terms System, Series and Stage to denote stratigraphic units which the United States Geological Survey would refer to as Supergroup, Group, and Formation.

Stage is predominantly arenaceous while the upper and lower stages are argillaceous. The Lower Ecça Stage ranges in thickness from 163 feet (49.7 m) to 274 feet (83 m) and consists almost entirely of clean, bluish-black shale with occasional small bands and laminae of sandstone near the base. The shale contains 12 percent of evenly distributed, finely disseminated carbonaceous matter.

The Middle Ecça Stage ranges in thickness from 1000 feet (305 m) to 1238 feet (377 m) and is largely composed of grit, coarse- and fine-grained sandstone, shaly sandstone, and shale deposited in a cyclic manner. The cyclothems have been interrupted, and no complete cyclothem is known to be preserved, the marine portions being almost invariably absent. In general they commence with a sandy shale and end with a coal seam. The middle portion of the stage is the most sandy and contains two economically important coal seams and as many as five minor ones. Some 430 feet (131 m) above the base of the Middle Ecça is a zone in which lenticular iron ore deposits are sporadically developed along an outcrop which extends from north to south a distance of at least 110 miles (177 km). They are, in many places, rich in plant impressions. One locality has yielded numerous fish scales, and the bed at the Aletta Iron Ore Mine has yielded fresh water lamellibranchs. The shale roof of the small coal seam overlying the iron ore bed at the Aletta Mine yielded the fossil cephalopods discussed herein. The rocks of the Middle

Ecça Stage are almost entirely of fresh water origin and both mega- and microfossils of the *Glossopteris* flora are well represented in them. Hart (1969) described acritarchs (Acanthomorphae) from several boreholes, indicative of marine conditions, while Le Roux (1960) described the conchostrachan *Cyzicus* sp. Intraformational conglomerate beds composed of mud flakes and pellets with a sandy matrix are fairly common in the lower portion of the stage. In many places, this conglomerate shows traces of rootlets and the casts of worm burrows. The rock in which the cephalopods occur is a thin-bedded to laminated, gray, fine-grained, micaceous sandstone.

The Middle Ecça Stage is overlain conformably by the Upper Ecça Stage, consisting of some 400 to 450 feet (122 to 137 m) of bluish-black shale containing 8 percent of finely disseminated carbonaceous matter with occasional phosphatic lenses and concretions. Hatch (1910a) noted *Acrolepis* sp., fish scales, and (1910b) mentioned labrinthodont bones in phosphatic nodules. Haughton (1920) noted a fragmentary reptilian jaw from the same nodules. Fucoid-like markings which are possibly the casts of worm-burrows are fairly widespread. The Ecça Series has been invaded by several dolerite sills and by numerous dolerite dykes (Fig. 1). These sills have altered the sediments by induration. Where the sills have invaded the Middle Ecça rocks, they tend to be concentrated in the shaly zones and have no doubt destroyed much of the fossil record.

MODE OF PRESERVATION

The two shells originally described by Rilet (1963), here redescribed as *Paraceltites? bowdeni* (Pl. 1, fig. 1,2), are compressed to quite flat discs, at the most 3 to 4 mm thick. There is no trace of any internal structures. Septa and siphuncle have disappeared and, consequently, no sutures can be observed. In contrast, features of the outer shell are reasonably well preserved, as described below. No accurate reconstruction of the original shape of the shells is possible, although there are indications that they were

rather narrowly discoidal, with small whorl width.

The strong lateral compression of the shells has caused intense fracturing of the shell walls and led to telescoping ("overthrusting" in A. Seilacher's terms) of the whorls. Essentially two sets of fractures are observed, one more or less radial, the other concentric. It was the radial set that had been mistaken for sutures in the earlier interpretation of the specimens. According to Seilacher (oral communication to Teichert, 1972)

FIG. 1. Geological map of vicinity of Aletta mine, north of Dundee, Natal, South Africa. (Based on Republic of South Africa Geological Series, 1:125,000, 2829B Elandslaagte and 2830A Dundee.)

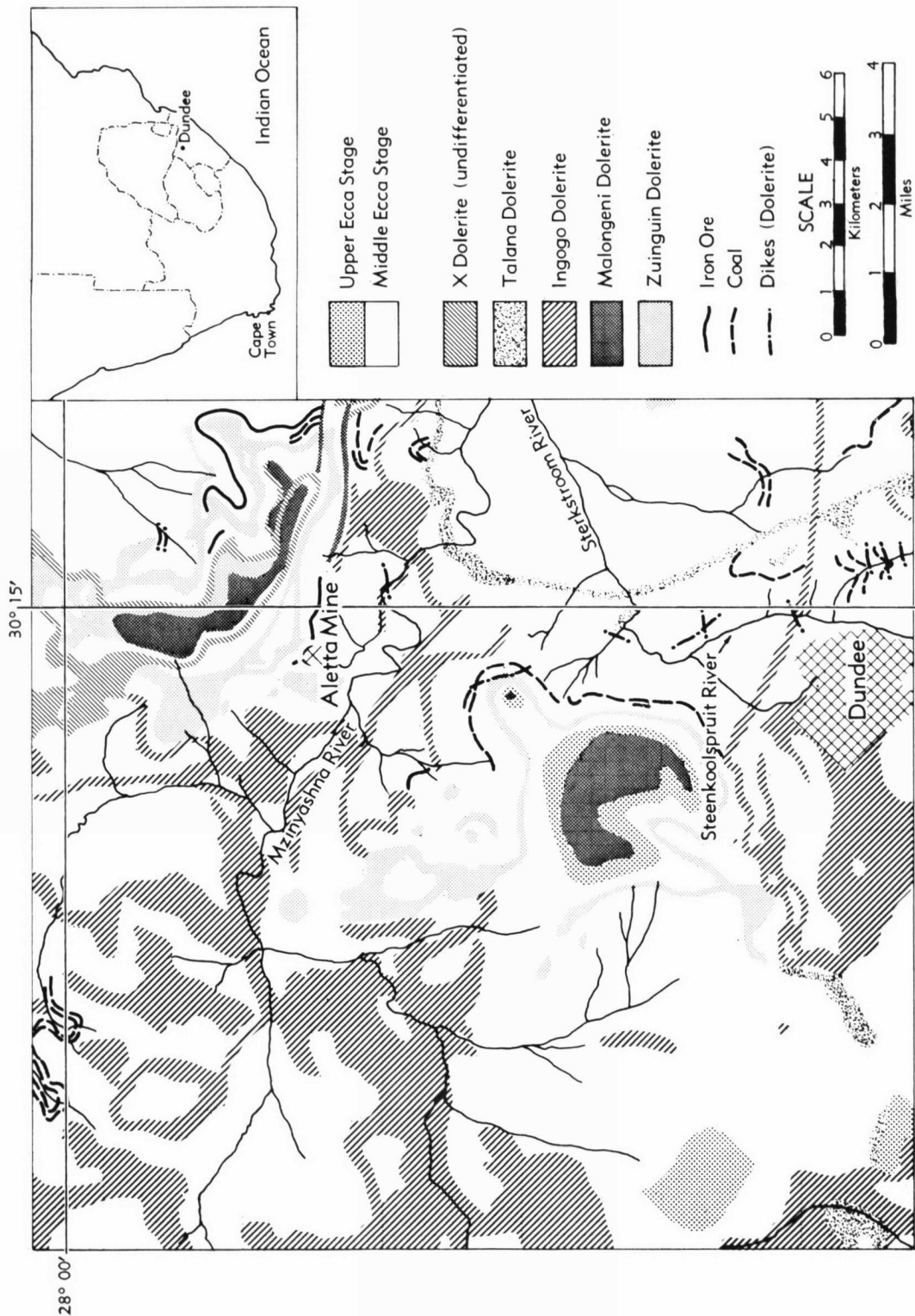


FIG. 1. (Explanation on facing page.)

this type of preservation is the rule in such deposits as the Lower Jurassic Holzmadener Schiefer, the Middle Jurassic Opalinus-Ton of southern Germany, and the Middle to Upper Jurassic Oxford Clay of England. According to Seilacher, the preservation of the *Ecca* specimens most resembles that of the ammonites in the Opalinus-Ton and Oxford Clay occurrences, where outer shell walls are preserved, but the entire septal apparatus and siphuncles have been removed by solution. In the Holzmaden occurrence, shells are usually also dissolved, but siphuncles may be preserved occasionally.

These phenomena have been little studied, or even mentioned, in the literature. In a broadly based study of the depositional environment of the Holzmadener Schiefer, Hauff (1921, p. 22) wrote (transl.): "The study of these [Lias] ϵ -ammonites is made very difficult by their compression into paper-thin discs and the complete absence of sutures, except in one species." The total number of ammonite species available to Hauff was 15. In a later publication, Hauff [Jr.] (1963, p. 31) wrote (transl.): "The ammonite shells in the Posidoniaschiefer [=Holzmadener Schiefer] are mostly preserved as entirely flat discs."

In 1932, Klähn published a somewhat detailed study of the effect of sediment load on the deformation of fossil shells, especially of bivalves and cephalopods. He described, among other things, the condition of flattened ammonite shells from Jurassic beds and mentions the "overthrusts" of some shell fragments upon others (Klähn, 1932, p. 65) as well as the characteristic combination of radial and concentric fractures, illustrated on a specimen of *Leioceras opalinum* Reineck from the Opalinus-Ton of Württemberg (ibid.,

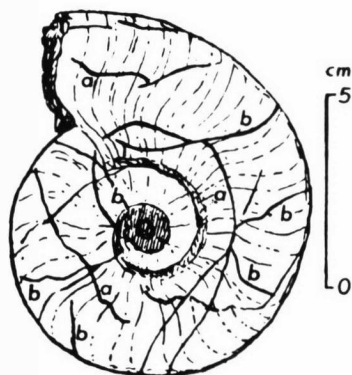


FIG. 2. Side view of strongly compressed shell of *Leioceras opalinum* (Reineck), Opalinus-Ton, Upper Jurassic, West Germany (from A. H. Müller, 1963, with the permission of the author). [a, concentric fractures; b, radial fractures.]

p. 66, 72). A very similar specimen of the same species was figured by Müller (1963, p. 98) from the same formation, but a different locality (Fig. 2). Both specimens show a pattern of radial and concentric cracks and "overthrusts" almost identical to that observed in the *Aletta* cephalopods.

More recently, Andalib (1972) has described similar preservation of ammonite shells in Upper Jurassic lithographic limestone from southern Germany: "They resemble 'sculpture steinkerns' in that they show all details of outside ornamentation but no suture lines."

We do not intend to pursue the problem of diagenesis of this type of collapsed ammonid shells, because Professor Seilacher is undertaking a more broadly based study of these phenomena. It was of concern, however, to point out that the state of preservation of the *Ecca* cephalopods is by no means unique.

ASSOCIATED FAUNA

The slab with the two cephalopod shells, figured by Rilett (1963, p. 11), also contains a fragment of a mytiloid bivalve, numerous small echinoid spines, and a few fragments of echinoid ambulacra. The spines (Pl. 1, fig. 3) are up to 10 mm long and 0.3-0.4 mm thick; some show a well developed annulus and base. The ambu-

lacrals fragments (Pl. 1, fig. 3) have two rows of tubercles, but other details are difficult to discern. It is probably safe to assume that these remnants belong to some kind of cidaroid echinoid.

An additional slab in private ownership contains a number of extremely faint linear impres-

sions one of which is ribbonlike and dichotomously branched and may be the impression of a bryozoan; others which are unbranched may

be crinoid stems. A slab owned by the Dundee Museum, now partially destroyed, showed the remnants of one indefinite foraminifer.

AGE AND ENVIRONMENT

As discussed below, *Paraceltites? bowdeni* is related to a group of cephalopods with narrowly discoidal, evolute shells, most of which are of Late Permian age. Only in the Glass Mountains of Texas is the stratigraphically lowest occurrence of *Paraceltites* in the Road Canyon Formation of latest Early Permian age (Cooper and Grant, 1972; p. 67; Furnish, 1973, p. 534). It is, therefore, considered likely that the bed of the Middle Eccla Stage in which *P.? bowdeni* occurs is of late Early or Late Permian age.

It is of interest that the marine bed with

Parceltites?, a mytiloid bivalve, and echinoid remains lies only 42 inches (150 cm) above a bed that contains freshwater bivalves (Rilett, 1951). This and other occurrences of marine deposits in the Middle Eccla confirm that these strata were laid down in a paralic environment, similar to the regime under which the Upper Carboniferous coal measures of western Europe were formed. Freshwater and brackish-water environments have, of course, also been present (McLachlan & Anderson, 1973).

SYSTEMATIC DESCRIPTION

Class CEPHALOPODA Cuvier, 1798

Order AMMONITIDA Agassiz, 1847

Family PARACELTITIDAE Spath, 1930

Spath (1930, p. 13) proposed the family Paraceltitidae for "striate and costate ophiocones, with compressed elliptical whorl-section and with simple suture-line" and included in it the genera *Atsabites* Haniel, *Epiglyphioceras* Spath, and doubtfully, *Clinolobus* Gemmellaro. Concepts of the scope of this family changed greatly with different authors (e.g., Plummer and Scott, 1937; Miller and Furnish, 1940; Kummel in Arkell *et al.*, 1957; Kiparisova in Luppov and Drushchits, 1958), but detailed taxonomic discussions are beyond the scope of the present paper.

Genus PARACELTTITES Gemmellaro, 1881

PARACELTTITES? BOWDENI (Rilett)

Plate 1, figures 1, 2

Discitoceras bowdeni n. sp., Rilett, 1963, p. 72-73, pl. 11.

Description: Evolute, discoidal shells, coiled in a plane spiral; whorls slightly overlapping; shells now collapsed to a thin disc, but were originally probably very narrow. Maximum diameter of holotype (Pl. 1, fig. 1) 45 mm, maximum height of last whorl at adoral end 13

mm; depth of impressed area of dorsal side at adoral end not more than 3 mm. The shell of the holotype is somewhat less strongly compressed than that of the smaller paratype (Pl. 1, fig. 3).

At the adoral end, for a distance of about 15 mm, a piece of rather abruptly rounded ventrolateral shoulder is exposed and the whorl here is at least 3 mm wide. At other places the shell seems to be less wide. The shell of the paratype is not more than 1 mm wide.

The surfaces of both specimens show very weak ribs and striae which are slightly sinuous. In places where they are relatively well preserved, they are placed about 0.7 to 0.8 mm apart, but near the adoral end of the shell the ribs develop into more closely spaced sinuous striae. This may suggest that the adoral end of the shell is close to the actual aperture and that the shell, therefore, is almost complete.

The initial part of the phragmocone is poorly preserved, but the umbilicus seems to be imperforate. The shell wall is composed of slightly iridescent material with colors, in reflected sunlight, showing brownish, yellowish, blueish and greenish hues. It might represent the original nacreous layers of the shell.

Discussion: The affinities of the present spe-

cies seem to be with a group of discoidal evolute ammonoids that are found worldwide in Upper Permian rocks and are usually referred to the families Xenodiscidae Frech, 1902, and Paracel-titidae Spath, 1930, although in Texas both families range into the upper part of the Lower Permian (Furnish, 1973). Kummel (in Arkell *et al.*, 1957, p. L130) placed the two families in synonymy and also placed here the Cibolitidae of Plummer and Scott (1937). However, it seems almost immaterial to which of these families the *Ecca* species is assigned because all known genera of all three of them occur in beds of very late Early and Late Permian age. It seems to us now that the similarities of the *Ecca* specimens may be closest with one of the several species of *Paracel-tites* Gemmellaro, 1887, as described by Plummer and Scott (1937) and by Miller and Furnish (1940).

Paracel-tites includes discoidal evolute shells in which the surface ornamentation consists of growth-lines and sinuous ribs (Miller and Furnish, 1940, p. 65-66). The ribs may be of widely varying strength, from strongly to weakly ribbed to species with no ribs, such as *P. altudense* (Böse) (see Plummer and Scott, 1937, pl. 37, fig. 11,13; Miller and Furnish, 1940, pl. 23, fig. 1-3). *P. bowdeni* resembles *P. ornatus* Miller and Furnish (1940, p. 68) from the Word Formation of the Glass Mountains Texas in the close spacing of the ribs. It might also fall

within the range of variants of *P. elegans* Girty as exhibited by the several specimens illustrated by Miller and Furnish (1940, pl. 22). But in general it seems to be most like *P. altudense*. Some of the specimens of this species figured by Miller (1944, pl. 4, esp. fig. 6) from Las Delicias, Coahuila, Mexico, show well developed, though weak, sinuous ribs, very similar to those of *P. bowdeni*.

All species of *Paracel-tites* have very narrow, slender shells and the width of most of them does not exceed 6 mm. Thus, the compression of the shells due to collapse was perhaps no more than 50-75 percent, which may account for the relatively good preservation of some surface features of the shells.

Among other narrowly discoidal forms of the Late Permian are the xenodiscids proper (Xenodiscidae Frech *s. str.*), but these are either ribless at maturity, as *Xenodiscites* Miller and Furnish (see Miller, 1944, p. 126), or have few straight, prorsiradiate ribs at varying stages of ontogeny, as *Xenodiscus* Waagen (= *Xenaspis* Waagen).

Stratigraphic Occurrence: Roof of the coal seam overlying the siderite deposit [in the Aletta iron mine].

Age: Late Early to Late Permian.

Locality: Aletta 4350, 7 miles (11 km) due north of Dundee Railway Station, northern Natal (see Fig. 1).

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EXPLANATION OF PLATE 1

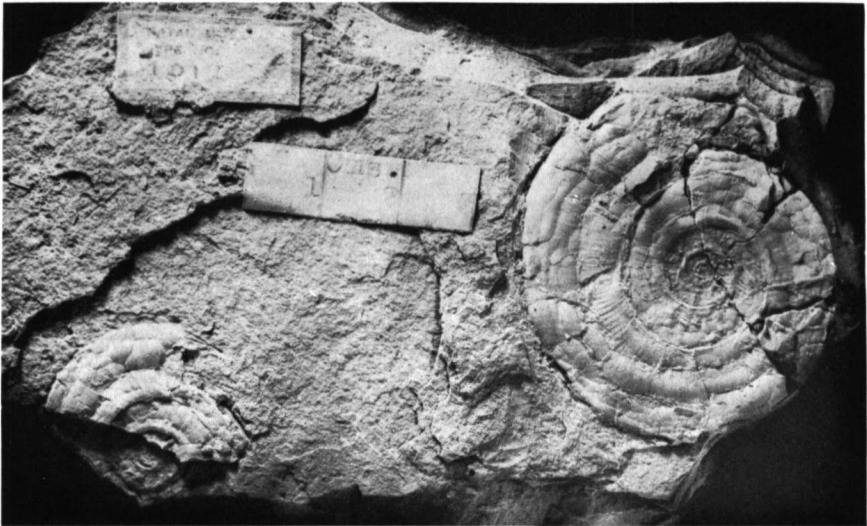
Paraceltites? bowdeni (Rilett) and echinoid remains,
No. 1012, Natal Museum, Pietermaritzburg, Natal.

FIGURE

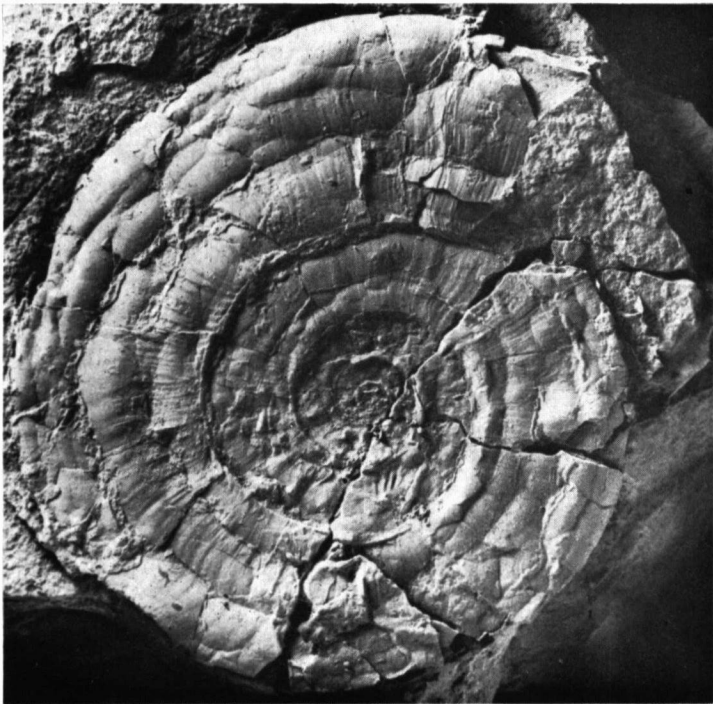
1. Entire sandstone slab with 2 specimens of *Paraceltites? bowdeni*; numerous echinoid spines and impressions in left part of slab, $\times 1$.
2. Larger specimen (holotype) shown in Figure 1, $\times 2$.

FIGURE

3. Outer molds of part of an ambulacrum and a small spine of an echinoid, from upper left corner of slab shown in Figure 1, $\times 10$.



1



2



3